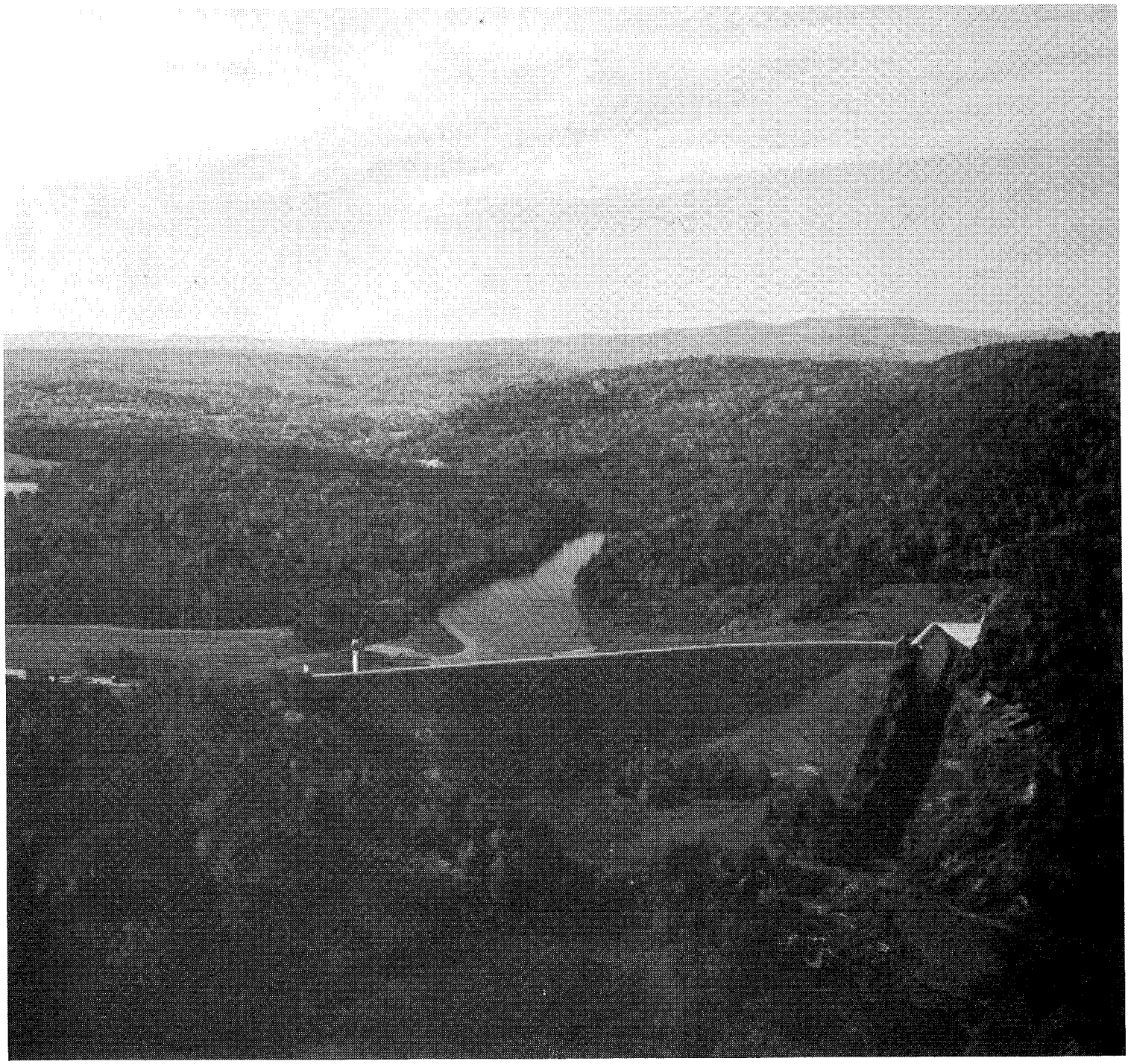
US Army Corps
of Engineers
New England Division

Drought Contingency Plan

SEPTEMBER 1987

North Hartland Lake, North Hartland, Vermont



CONNECTICUT RIVER BASIN
OTTAUQUECHEE RIVER WATERSHED

DROUGHT CONTINGENCY PLAN
NORTH HARTLAND LAKE

1987

NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254-9149

SYLLABUS

This report is a compilation of basic information on the Corps of Engineers North Hartland Lake to aid the assessment of the project as an emergency domestic water supply source. Included are sections on project description, operating procedure, available storage capacity, water quality, and water supply systems in the region. It is not within the scope of this study to perform detailed analyses but mainly to address the emergency potential of the site and identify and discuss a variety of concerns to be considered in weighing North Hartland versus any other available sources of emergency supply. A review for compliance with all current applicable environmental, riparian or other laws would be required at the time of any decision to pursue drought contingency storage at the project. The Corps of Engineers would not consider drought storage activities at North Hartland Lake without an official request from the State of Vermont.

North Hartland Lake is located in central Vermont on the Ottauquechee River. Ten surrounding towns have a total population of 23,220 and are serviced by 12 water supply systems. A 2350 AC-FT permanent pool currently exists at the project. Hydropower operation currently regulates the use of this pool during non-flood periods. Further encroachment on the flood control storage at North Hartland Lake is not considered feasible. However a low flow duration analysis was performed to calculate the magnitude of flow available at the project under emergency drought conditions.

Water quality at North Hartland Lake is good and would be suitable for public water supply with proper treatment.

DROUGHT CONTINGENCY PLAN
NORTH HARTLAND LAKE

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NORTH HARTLAND LAKE

1. PURPOSE AND SCOPE

The purpose of this study and report was to develop and set forth a drought contingency storage plan of operation for North Hartland Lake that would be responsive to public needs during drought periods and identify possible modifications to project regulation within current administration and legislative constraints. This plan was based on preliminary studies utilizing readily available information. Included are a description of existing water supply conditions, the potential for allocation of reservoir storage within specified limits, an evaluation of water quality, a discussion of impacts on other project purposes, the effects on the environment and summary and conclusions.

2. AUTHORIZATION

The authority for the preparation of drought contingency plans is contained in ER 1110-2-1941 which provides that water control managers will continually review and, when appropriate, adjust water control plans in response to changing public needs. Drought contingency plans will be developed on a regional, basin-wide and project basis as an integral part of water control management activities.

3. PROJECT AUTHORIZATION CONDITIONS

North Hartland Lake was authorized by the Flood Control Act of 28 June 1938, (Public Law 761, 75th Congress). Construction of the project was initiated in June 1958 and completed in June 1961. A summer season recreational pool was authorized at a stage of 35 feet in May 1967. In November 1981, the Federal Energy Regulatory Commission issued a license to the Vermont Electric Cooperative authorizing them to harness the recreation pool head at North Hartland for hydropower generation.

4. PROJECT DESCRIPTION

North Hartland Lake is a multi-purpose flood control, recreational and hydropower generating facility located in North Hartland, Vermont on the Ottauquechee River in the Connecticut River Basin. A map of the Connecticut River Basin is shown on plate 1 and an Ottauquechee river watershed map is shown on plate 2.

At spillway crest (elevation 546.5 feet-NGVD), the reservoir has a capacity of 71,000 acre-feet of storage equivalent to 6.06 inches of runoff from the contributing drainage area of 220 square miles. When filled to spillway crest, a 1,100 acre pool, extending 5.5 miles upstream of North Hartland Dam, is created. A capacity table is shown on plate 3.

The physical components of North Hartland Lake consist of a rolled earthfill dam and dike, an L shaped side channel spillway, outlet works, recreational facilities and a 4 megawatt hydropower generating plant.

A summary of pertinent data at North Hartland Lake is shown on plate 4.

5. PRESENT OPERATING REGULATIONS

a. Normal Periods: A 35 ft permanent pool is maintained year round by gate regulation at the project. Before the installation of hydropower facilities at North Hartland Lake, this pool was maintained to prevent the flood control gates from freezing in the winter and to provide recreational activities at the reservoir during other times of the year. Presently the pool is maintained to ensure adequate head and discharge for hydropower generation. The power pool normally fluctuates between a stage of 32 to 35 feet.

b. Flood Periods: Flood control is the primary purpose of North Hartland Lake and will take precedence over all other activities at the project. North Hartland Lake is operated in conjunction with other projects within the Connecticut River basin, to reduce downstream flood stages along the Connecticut River.

Operations for floods may be considered in three phases: phase I - appraisal of storm and river conditions during development of a flood, phase II - flow regulation and storage of flood runoff at the reservoir, and phase III - emptying the reservoir during recession of the flood. The regulation procedures are detailed in Appendix B of the Master Water Control Manual for the Connecticut River basin.

c. Regulating Constraints:

(1) Minimum Releases: A minimum instantaneous release of 23 cfs (July through October) and 40 cfs (November through June) is automatically maintained through a low flow diversion structure provided by the Vermont Electric Generator and Transmission Cooperative, operators of the hydropower facility.

(2) Maximum Releases: The maximum nondamaging discharge immediately downstream of North Hartland is about 6,000 cfs.

6. MONITORING OF HYDROLOGIC CONDITIONS

The Reservoir Control Center directs the reservoir regulation activities at 31 New England Division flood control dams and continually monitors rainfall, snowcover and runoff conditions throughout the region. When any of these hydrologic parameters have been well below normal for several months and it appears that possible drought conditions might develop, the Corps Emergency Operations Center (EOC) will be so

informed. The EOC will then initiate discussions with the respective Federal and State agencies and other in-house Corps elements to review possible drought concerns and future Corps reservoir actions.

7. DESCRIPTION OF EXISTING WATER SUPPLY CONDITIONS

a. General: The area of concern is a portion of the southeast central region of Vermont in the vicinity of North Hartland Lake. Table 1 contains information about public water suppliers in this area based on information provided by the Vermont Department of Health. Of the 10 communities viewed as potential users of water from North Hartland Lake during drought conditions, 7 of the communities are at least partially served by public or privately owned water supply systems. Included in Table 1 are only those systems with at least 20 service connections and a maximum daily demand of at least 0.01 mgd. No data is available for those areas dependent on private individual water supplies.

b. Water Supply Systems: The primary objective of this analysis was to accumulate available data regarding water supply systems in the vicinity of North Hartland Lake that could benefit from storage at the project, and to present the data in a manner portraying existing water supply conditions. Projections of future demands were not developed because this study addresses only modifications in the operational procedures at North Hartland Lake in order to provide storage for water supply purposes when drought conditions exist, and not to meet normal water supply demands at some future date.

c. Public Water Suppliers: As noted in Table 1, the data given for each water supplier includes: community served, number of service connections for the system, estimated population served by the system, source of supply (ground or surface water), average day and maximum day demands for 1981, estimated safe yield of the source, and any further information available on the source of supply. An analysis of the adequacy of existing sources during drought conditions has not been performed. The information is shown to present a summary of the existing water supply conditions for the southeast central Vermont area. Communities in the vicinity of North Hartland Lake without any water supply systems include Bridgewater, Pomfret, and Reading.

d. Population Projections: Population projections for communities in the study area are given in Table 2 to show population trends for each community potentially affected by a prolonged dry period. The population projections were provided by the Vermont State Planning Office. Projections used in this report are from the high series developed by the state, which assume that migration rates through the year 2000 will continue at the rate observed from 1970-1980.

Table 1
Major Water Suppliers - Southeast Central Vermont

Company or Agency	Town Served	Service Connections	Est. Population Served -- 1981	Source of Supply (SW/GW)	1981 Demand Avg. Day (MGD)	1981 Demand Max. Day (MGD)	Supply Source	Safe Yield (MGD)
Sonnenberg Water Syst.	Barnard	20	75	GW	0.005	0.010	Rock Well	N/A
	Bridgewater			No central supply				
Hartford Water Dept.	Hartford	1552	5,000	GW/SW	0.830	1.400	Gravel Well Wright Reservoir (emergency)	2.000 N/A
Merrimac Manor Mobile Home Park	Hartford	30	120	GW	0.008	0.015	Rock Well	0.012
Quechee Central	Hartford	660	2,000	GW	0.095	0.424	Gravel Well	1.000
Woodside Manor	Hartford	25	60	GW	0.008	0.016	Rock Well	0.720
North Hartland Water Co-op	Hartland	90	320	GW	0.024	0.090	Gravel Well	0.011
Interval Resort, Inc.	Plymouth	60	240	GW	0.018	0.036	Rock Well	N/A
Ledges System #1	Plymouth	30	150	GW	0.011	0.023	Rock Well	0.044
	Pomfret			No central supply				
	Reading			No central supply				
Summit Water Co., Inc.	West Windsor	236	500	GW	0.048	0.096	Rock Well #1 (permanent) Norton Line Spring (standby)	0.180
Windsor Water Dept.	Windsor	900	3,700	GW	2.300	3.000	Well #1 Well #3	2.000 2.440
Churchill Trailer Park	Woodstock	40	130	GW	0.010	0.020	Two Gravel Wells	0.022
Woodstock Aqueduct Co.	Woodstock	600	2,000	GW/SW	0.150	0.300	Gravel Well Cox Reservoir	N/A N/A

N/A - Not Available

Table 2
Population Projections - Southeast Central Vermont

Town	Actual 1980	1985	1990	1995	2000	Percent Change 1980-2000
Barnard	790	858	926	984	1,032	30.63
Bridgewater	867	902	937	976	1,008	16.26
Hartford	7,963	8,439	8,925	9,380	9,752	22.47
Hartland	2,396	2,577	2,762	2,923	3,055	27.50
Plymouth	405	443	481	513	539	33.09
Pomfret	856	928	1,002	1,064	1,115	30.26
Reading	647	677	707	739	765	18.24
West Windsor	763	822	882	934	977	28.05
Windsor	4,084	4,165	4,245	4,384	4,496	10.09
Woodstock	3,214	3,407	3,605	3,789	3,940	22.59
	21,985	23,218	24,472	25,686	26,679	21.35

8. POTENTIAL FOR WATER SUPPLY REALLOCATION

a. General: There are several authorities that provide for the use of reservoir storage for water supply at Corps of Engineers projects. They vary from the provision of water supply storage as a major purpose in new projects to the discretionary authority to provide emergency supplies to local communities in need. In addition, guidance contained in ER 1110-2-1941 directs field offices to determine the short-term water supply capability of existing Corps reservoirs. Congressional authorization is not required to add municipal and industrial water supply if the related revisions in regulation would not significantly affect operation of the project for the originally authorized purposes.

b. Drought Contingency Storage: A 2,350 ac-ft permanent pool currently exists at North Hartland Lake. Further encroachment on the flood control storage at the project is not considered feasible. The hydropower operation currently regulates the use of the permanent pool during non-flood periods. The pool fluctuates from a stage of 32 to 35 feet during normal hydropower operations. The hydropower generating units are designed for the head currently existing at the project. Raising the pool significantly for drought contingency storage would negate current hydropower operating procedures. Therefore, drought contingency storage would be precluded at North Hartland Lake.

However, a low flow duration analysis was performed to calculate the magnitude of flow available at North Hartland under emergency drought conditions. Based on an all-season low flow duration analysis using 53 years of flow records at the Ottauquechee River gaging station downstream of the dam, 10 year frequency low flows were developed and are shown on Table 3. In an emergency, the water in the existing hydropower pool plus inflows to the project could be used. The 2,350 ac-ft of existing storage plus project inflows would provide a 10% chance (10 yr) and 1% chance (100 yr) dependable yield of about 40 MGD and 32 MGD, respectively.

c. Effect of Diverted Flows: The diversion of flows from the Ottauquechee River at North Hartland Lake during a drought emergency could adversely impact on the flowage rights of downstream riparian users. At this time, however, it is not possible to review all the various drought emergency situations that could occur, nor is it within the scope of this report to identify all those with water rights.

In a drought emergency the goal would be to operate in the public interest established by weighing the needs and rights of known users and through consultation with responsible state officials.

TABLE 3
NORTH HARTLAND LAKE
ALL SEASON LOW FLOW DURATION

Low Flow Period (Days)	10% Change (10-yr) Avg. Low Flow (cfs)	1% Chance (100 yr) Avg. Low Flow (cfs)
1	5.9	2.6
3	12.5	6.6
7	22.5	13.6
14	25.5	14.7
30	33.8	23.2
60	42.6	29.3
90	50.2	34.0
120	56.4	36.9

9. WATER QUALITY EVALUATION

a. Water Quality Classification: The entire length of the Ottauquechee River and its tributaries are given a class B classification by the Vermont Water Resources Board (VWRB). The Ottauquechee River from Dewey's Mills Pond to the confluence with the Connecticut River is further designated as a warm water fish habitat by the VWRB. These are not statements of the existing water quality conditions in the river but rather of the water quality goals for the Ottauquechee River.

Class B waters are managed to achieve a high level of quality which consistently exhibits good aesthetics and provides high quality habitat for aquatic biota, fish and wildlife. Class B waters are usable for public water supply after filtration and disinfection; irrigation and other agricultural uses; swimming and recreation.

Criteria for class B warm water fisheries include a minimum dissolved oxygen (DO) level of 5 mg/l or 60 percent of saturation at all times, pH in the range of 6.5 to 8.0, turbidity not to exceed 1 NTU, fecal coliforms not to exceed 200 organisms per 100 ml, and color not to exceed 25 standard color units. There shall be no increase in nutrients which would accelerate eutrophication, and the waters shall be managed so as to prevent the discharge of toxic wastes in concentrations, quantities or combinations that may create a significant likelihood of an adverse impact on human health or acute or chronic toxicity to fish or wildlife.

b. Existing Water Quality:

The water quality at North Hartland Lake is generally good, usually meeting or exceeding the class B standards for Vermont. Indicative of its good water quality are consistently high DO levels, neutral to alkaline pH levels, and generally low levels of color, turbidity, and coliform bacteria. Levels of algal nutrients are below the threshold concentrations to support algal blooms in an impoundment.

The principal water quality concern identified by NED's water quality monitoring program was occasional elevated mercury measurements. Although most mercury determinations found are less than detectable levels, measurements of up to 1.8 ug/l have been recorded. This is higher than the average criteria to protect aquatic life and higher than the criteria for drinking water. However, the mercury levels at North Hartland Lake are typical of what has been found at many NED projects and there are no indications that aquatic life are being harmed by the mercury levels at any NED projects. If the water at North Hartland Lake were to be used for public water supply, the mercury levels should be monitored.

Occasional elevated levels of coliform bacteria, turbidity, and color are recorded at North Hartland Lake. These are likely due to storms washing these materials directly into the river. However, the presence of upstream wastewater treatment plants (WWTP) makes it possible that some high coliform counts may be due to WWTP malfunctions.

c. Water Quality Requirements for Drought Storage:

There are two requirements to be met. The waters must meet state standards for surface waters and must be of a quality appropriate for the water supply user. A water which meets class B standards in Vermont is usable for public water supply with filtration and disinfection. The water quality required for industrial water supply depends on the industrial processes involved. The water at North Hartland Lake would be of a quality suitable for irrigation or firefighting.

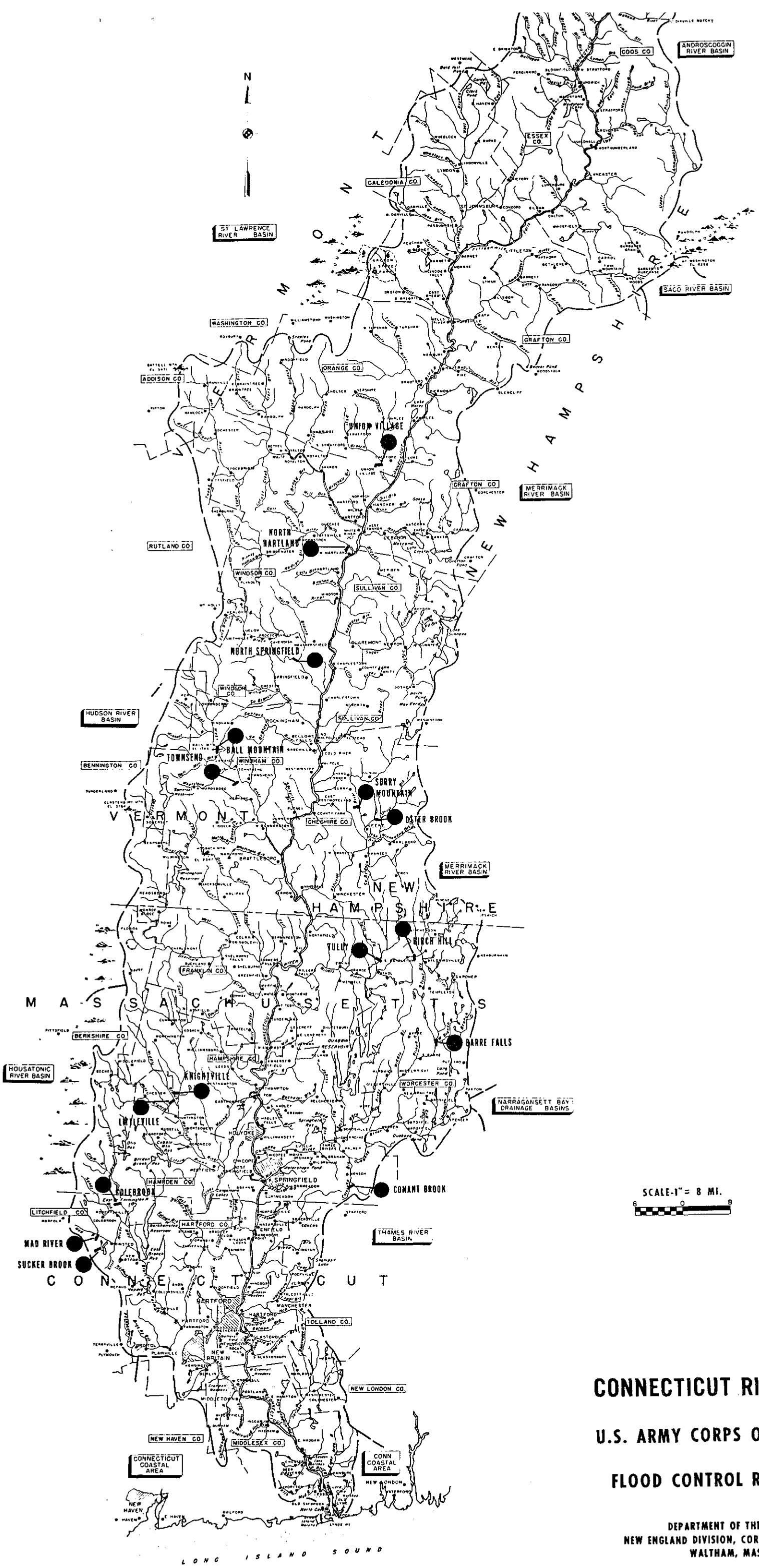
d. Water Quality Conclusions:

The water at North Hartland Lake is of good quality and should be suitable for public water supply following filtration and disinfection. No treatment should be required for the water to be acceptable for firefighting, irrigation, groundwater recharge, or some industrial processes. If the water at North Hartland Lake were to be used for water supply, a sampling program should be implemented at the lake to monitor levels of coliform bacteria, turbidity, and heavy metals including mercury.

10. SUMMARY AND CONCLUSIONS

North Hartland Lake is located on the Ottauquechee River in central Vermont in a region where existing 12 water supply systems service about 23,220 people. Because of current hydropower operation and the already existing permanent pool, it was concluded that further encroachment on the flood control storage for drought contingency was not feasible.

Water quality is good at North Hartland and could be used as a public water supply source with proper treatment. A low flow analysis was performed to calculate the existing dependable yield of the project under emergency drought conditions. However, diversion of river flows for the purpose of water supply could adversely impact flowage rights of downstream riparian users.



CONNECTICUT RIVER BASIN

U.S. ARMY CORPS OF ENGINEERS

FLOOD CONTROL RESERVOIRS

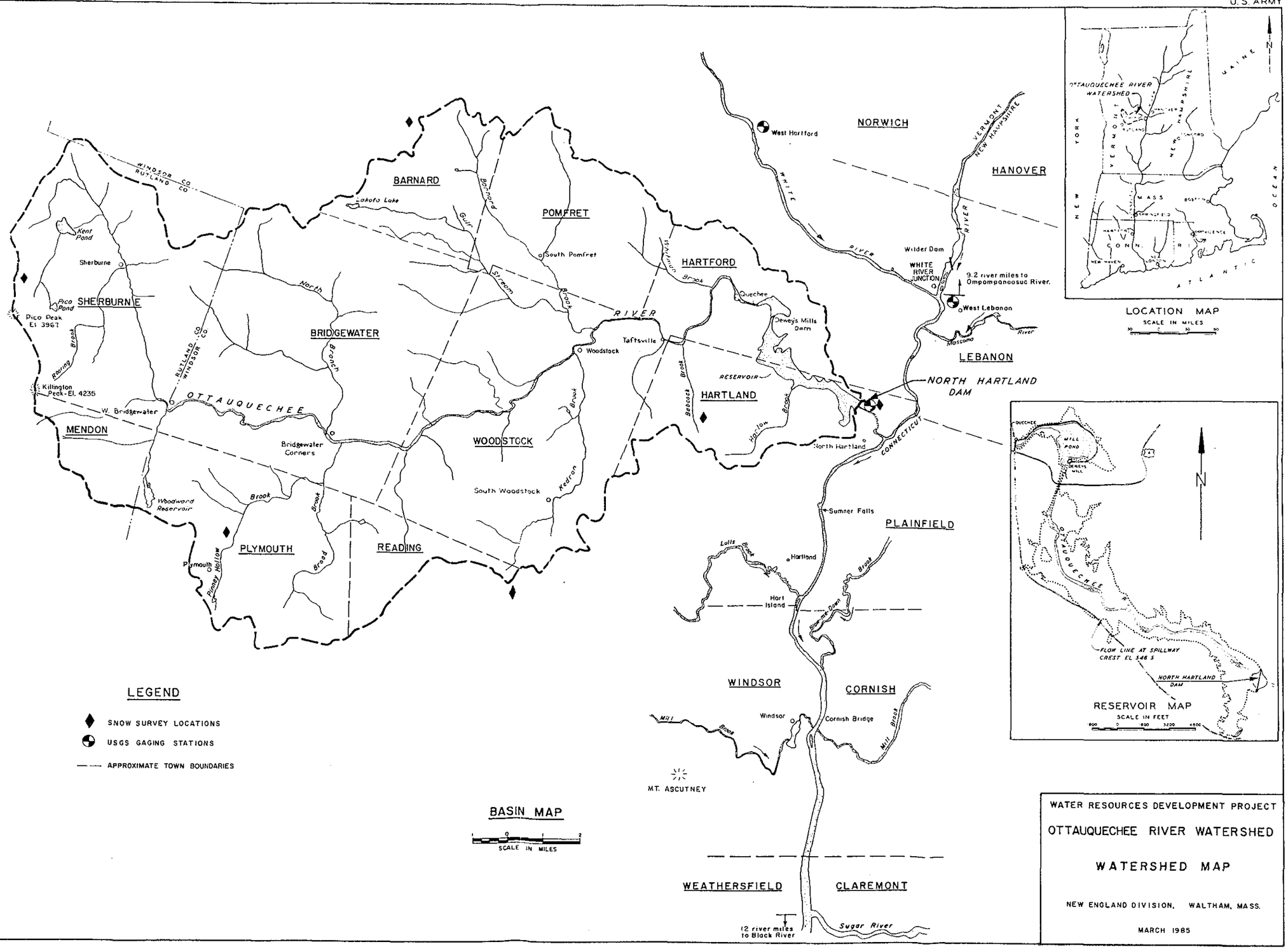
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS.

JANUARY 1981

PLATE I

CORPS OF ENGINEERS

U.S. ARMY



WATER RESOURCES DEVELOPMENT PROJECT

OTTAUQUECHEE RIVER WATERSHED

WATERSHED MAP

NEW ENGLAND DIVISION, WALTHAM, MASS.

MARCH 1985

PLATE 2

NORTH HARTLAND RESERVOIR

AREA - CAPACITY TABLE
(D.A. = 220 SQUARE MILES)

Elevation (msl)	Stage (ft)	Area (acres)	Total Capacity Ac/Ft	Total Capacity Inches	Flood Control Ac/Ft	Flood Control Inches
390	0	Gate Invert Elevation				
395	5	10.	50.	.01		
400	10	30.	100.	.01		
405	15	50.	250.	.02		
410	20	80.	500.	.04		
415	25	130.	825.	.05		
420	30	170.	1250.	.11		
425	35	215.	2350.	.20		
		Permanent Pool Elevation = 425 Ft. NGVD				
430	40	255.	3400.	.29	1050.	.09
435	45	280.	4825.	.41	2475.	.21
440	50	305.	6225.	.53	3875.	.33
445	55	330.	7875.	.67	5525.	.47
450	60	355.	9525.	.81	7175.	.61
455	65	380.	11450.	.97	9100.	.77
460	70	410.	13350.	1.14	11000.	.94
465	75	430.	15550.	1.31	13150.	1.11
470	80	450.	17650.	1.50	15300.	1.30
475	85	470.	20000.	1.70	17650.	1.50
480	90	495.	22350.	1.90	20000.	1.70
485	95	505.	24950.	2.12	22600.	1.92
490	100.	540.	27525.	2.34	25175.	2.14
495	105	560.	30325.	2.58	27975.	2.38
500	110	595.	33100.	2.82	30750.	2.62
505	115	620.	36250.	3.09	33900.	2.89
510	120	650.	39400.	3.36	37050.	3.16
515	125	685.	42825.	3.65	40475.	3.45
520	130	715.	46200.	3.94	43850.	3.74
525	135	815.	50300.	4.27	47950.	4.07
530	140	915.	54375.	4.63	52025.	4.43
535	145	975.	59250.	5.05	56900.	4.85
540	150	1030.	64100.	5.46	61750.	5.26
545	155	1085.	69500.	5.92	67150.	5.72
546.5	156.5	1100.	71100.	6.06	68750.	5.86
		Spillway Crest Elevation = 546.5 Ft. NGVD				
550	160	1140.	74900.	6.38	72550.	6.18
555	165	1235.	81100.	6.92	78750.	6.71
560	170	1330.	87300.	7.42	84950.	7.25
570	180	1480.	101400.	8.65	99050.	8.45

PERTINENT DATA
NORTH HARTLAND DAM

LOCATION	Ottauquechee River; North Hartland, Vermont
DRAINAGE AREA	220 Square Miles
STORAGE USES	Flood Control, Hydropower, Recreation

RESERVOIR STORAGE

	Elevation	Stage	Area	Capacity Acre-Feet	Capacity Inches on Drainage Area
Inlet Elevation	390.0	0			
Permanent Pool	425.0	35	215	2,350	0.20
Spillway Crest	546.5	156.5	1,100	71,000	6.06
Maximum Surcharge	566.8	176.8	1,430	25,800 (net)	2.02 (net)
Top of the Dam	572.0	182	-	-	-

EMBANKMENT FEATURES

	Main Dam	Dike
Type	Rolled earth and rockfill	Rolled earth and rockfill
Length (Feet)	1,640	2,110
Top Width (Feet)	24	24
Top Elevation (Ft. NGVD)	572	572 - 574
Maximum Height (Feet)	185	52
Volume (cubic yards)	1,800,000	600,000

SPILLWAY FEATURES

Location	Left abutment of dam
Type	L - shaped side channel with ogee weir
Crest Length (Feet)	465
Maximum Surcharge (ft. above crest)	20.3
Maximum Discharge Capacity (CFS)	160,900

SPILLWAY DESIGN FLOOD

Peak Inflow (CFS)	199,000
Peak Outflow (CFS)	171,000
Volume of Runoff (acre feet)	202,000

OUTLET WORKS

	Main Embankment	Dike
Tunnel	(1) concrete circular conduit	(1) concrete circular conduit
Tunnel size	14'4"	36" diameter
Steel liner and penstock	12'0"	None
Length	Concrete conduit - 743 Ft. Steel Liner - 551.5 Ft. Steel Penstock - 493 Ft.	476 Ft.
Service gates	Bypass Control Gate: Type - (1) radial slide gate Size - 8'4" wide x 12' high	Type - (1) vertical sluice Size - 3' x 3'
	Upstream Flood Control Gates: Type - (3) hydraulic driven vertical slide gate Size - 5'8" wide x 10' high	
Downstream Channel Capacity	6,000 CFS±	
Maximum Conduit Discharge at Spillway Crest	7,000 CFS	
Minimum Flow Requirement	23 CFS (July - October) 40 CFS (November - June)	

HYDROPOWER FACILITIES

Capacity (kilowatts)	4,000
Rated Flow (CFS)	810
Minimum Useable Flow (CFS)	215
Net Head (Feet)	66
Units	One vertical tube double-regulated Kaplan
Date Completed	July 1985

LAND ACQUISITION

Fee Elevation (Ft. NGVD)	505
Easement (Ft. NGVD)	550

MAXIMUM POOL OF RECORD

Date	April 1969
Stage (Feet)	129.0
Elevation(Ft. NGVD)	519.0
Percent Full	63

PLATE 4